Распараллеливание Data-Intensive приложений с помощью библиотеки DISLIB на десятки тысяч ядер

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Т-Платформы
Member of Graph500 Steering Committee

What is the Graph500?

- New benchmark to complement the Top 500 for large-scale data analysis problems
- International Multidisciplinary Steering Committee
  - Jim Ang, David A. Bader, Brian Barrett, Jon Berry, Bill Brantley, Almadena Chtchelkanova, John Daly, John Feo, Michael Garland, John Gilbert, Bill Gropp, Bill Harrod, Bruce Hendrickson, Anton Korzh, Jure Leskovec, Bob Lucas, Andrew Lumsdaine, Mike Merrill, Hans Meuer, David Mizell, Shoaib Mufti, Richard Murphy, Nick Nystrom, Fabrizio Petrini, Wilf Pinfold, Steve Poole, Arun Rodrigues, Rob Schreiber, John Simmons, Marc Snir, Thomas Sterling, Blair Sullivan, T.C. Tuan, Jeff Vetter, Mike Vildibill
- Three Kernels
  - Search (Concurrent Search, the Ranking Kernel)
  - Optimization (Single Source Shortest Path, almost released)
  - Edge Oriented (Maximal Independent Set, in specification)

GRAPH 500 Georgia Tech Argonne NATIONAL LABORATORY Sandia National Laboratories

History of the Graph500

- Graph500 announced at ISC10 (June 2010)
- 1st Graph500 List: 9 machines at SC10 (Nov. 2010)
- 2nd Graph500 List: 29 machines at ISC11 (June 2011)
- 3rd Graph500 List: 51 machines at SC11 (Nov. 2011)
- 4th Graph500 List: 88 entries at ISC 12 (June 2012)
- 5th Graph500 List: 124 entries at SC12 (Nov. 2012)
- 6th Graph500 List: 142 entries at ISC13 (June 2013)
- 7th Graph500 List: 160 entries at SC13 (Nov. 2013) [TODAY!]

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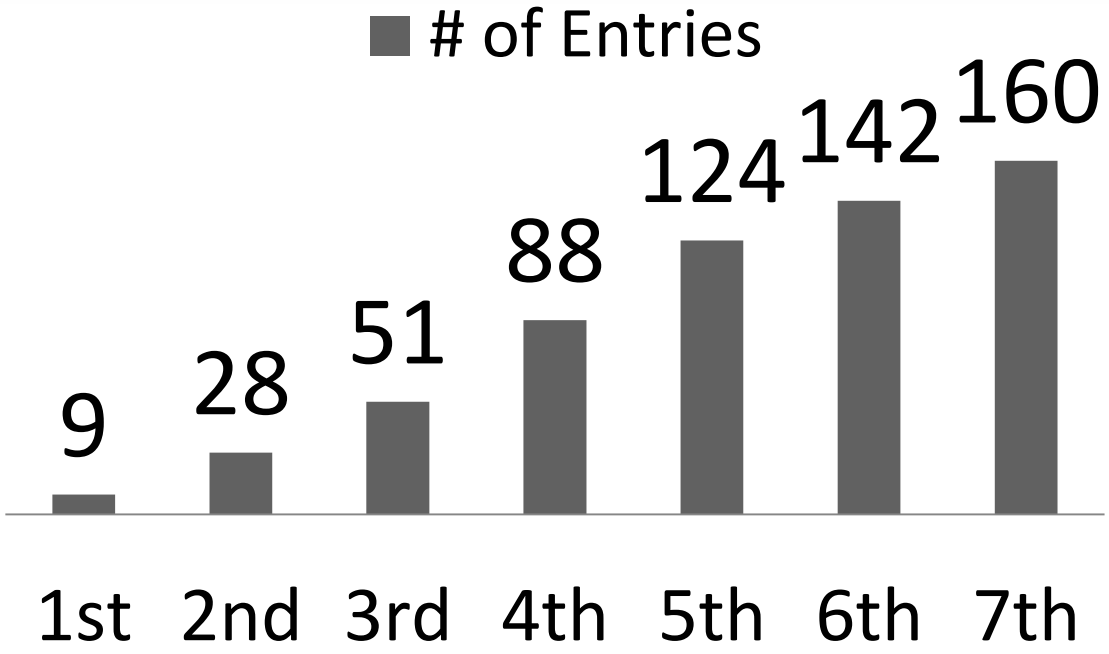
Five Business Areas

- Cybersecurity
  - 15 Billion Log Entires/Day (for large enterprises)
  - Full Data Scan with End-to-End Join Required
- Medical Informatics
  - 50M patient records, 20-200 records/patient, billions of individuals
  - Entity Resolution Important
- Social Networks
  - Example, Facebook, Twitter
  - Nearly Unbounded Dataset Size
- Data Enrichment
  - Easily PB of data
  - Example: Maritime Domain Awareness
    - Hundreds of Millions of Transponders
    - Tens of Thousands of Cargo Ships
    - Tens of Millions of Pieces of Bulk Cargo
    - May involve additional data (images, etc.)
- Symbolic Networks
  - Example, the Human Brain
  - 25B Neurons
  - 7,000+ Connections/Neuron

www.GRAPH500.org

7th Graph 500 List
(followed by special highlights)



7th Graph 500 List

Country	# entries	% entries
Amsterdam	2	1.3%
Australia	1	0.6%
Canada	3	1.9%
China	6	3.8%
France	2	1.3%
Germany	3	1.9%
Italy	2	1.3%
Japan	39	24.4%
Luxembourg	1	0.6%
Poland	1	0.6%
Russia	6	3.8%
Russian Federation	1	0.6%
South Korea	1	0.6%
Switzerland	6	3.8%
Taiwan	6	3.8%
UK	4	2.5%
USA	76	47.5%
Grand Total	**160**	

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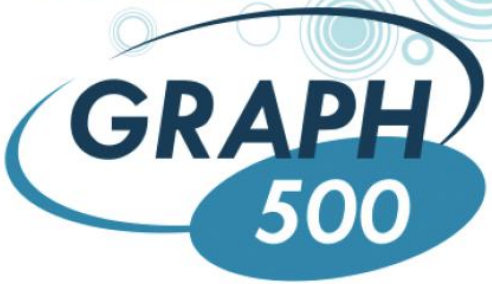
Lawrence Livermore National Laboratory's
DOE/NNSA/LLNL Sequoia
is ranked

on the Graph500 Ranking of Supercomputers with
15363 GE/s on Scale 40
on the 7th Graph500 list published at the International Supercomputing Conference, November 19, 2013.

Congratulations from the Graph500 Executive Committee



David A. Bader
David A. Bader

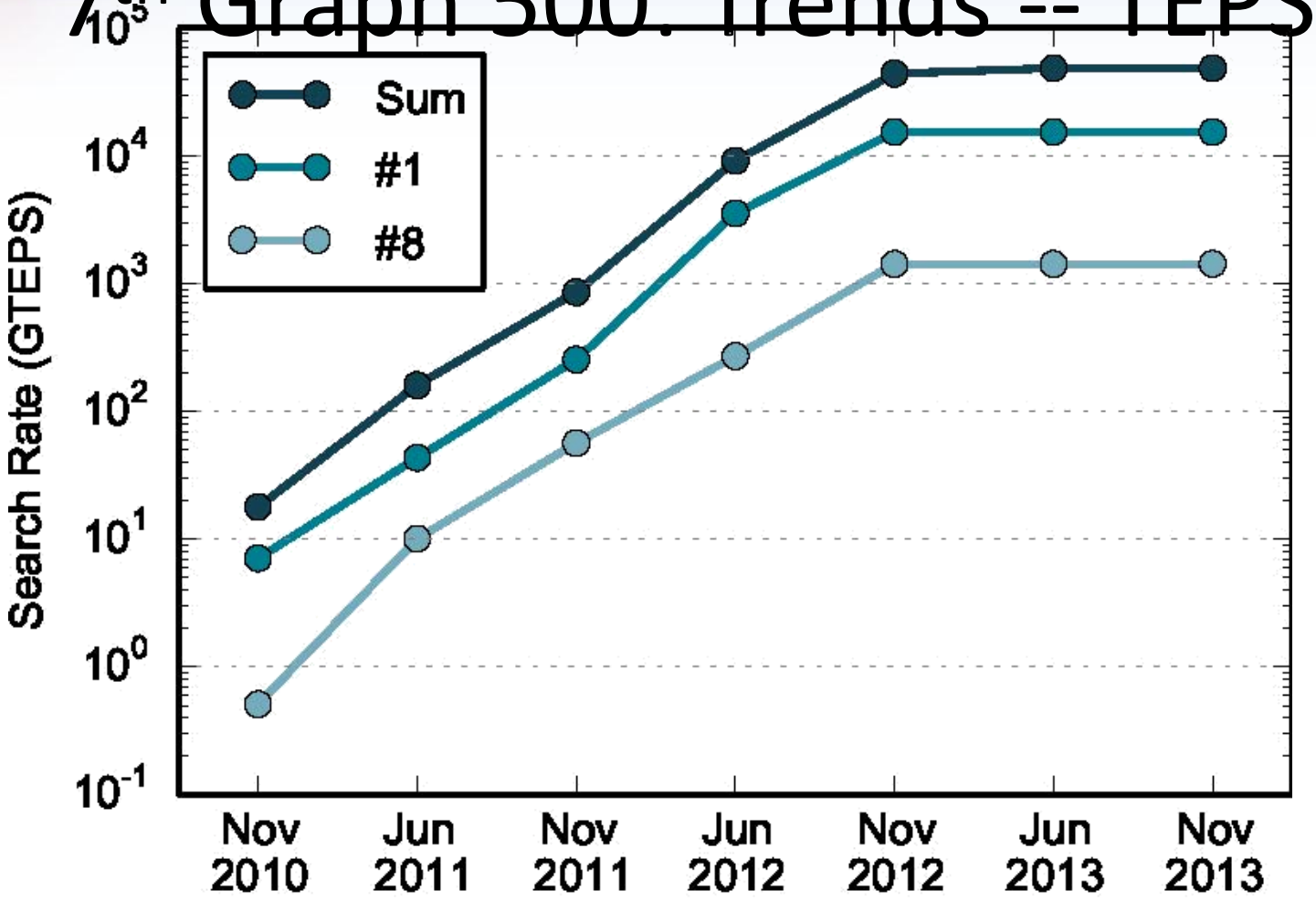
Andrew Lumsdaine

Richard Murphy

Marc Snir

Graph500 Executive Committee

7th Graph 500: Trends -- TEPS



Slide credit: Scott Beamer

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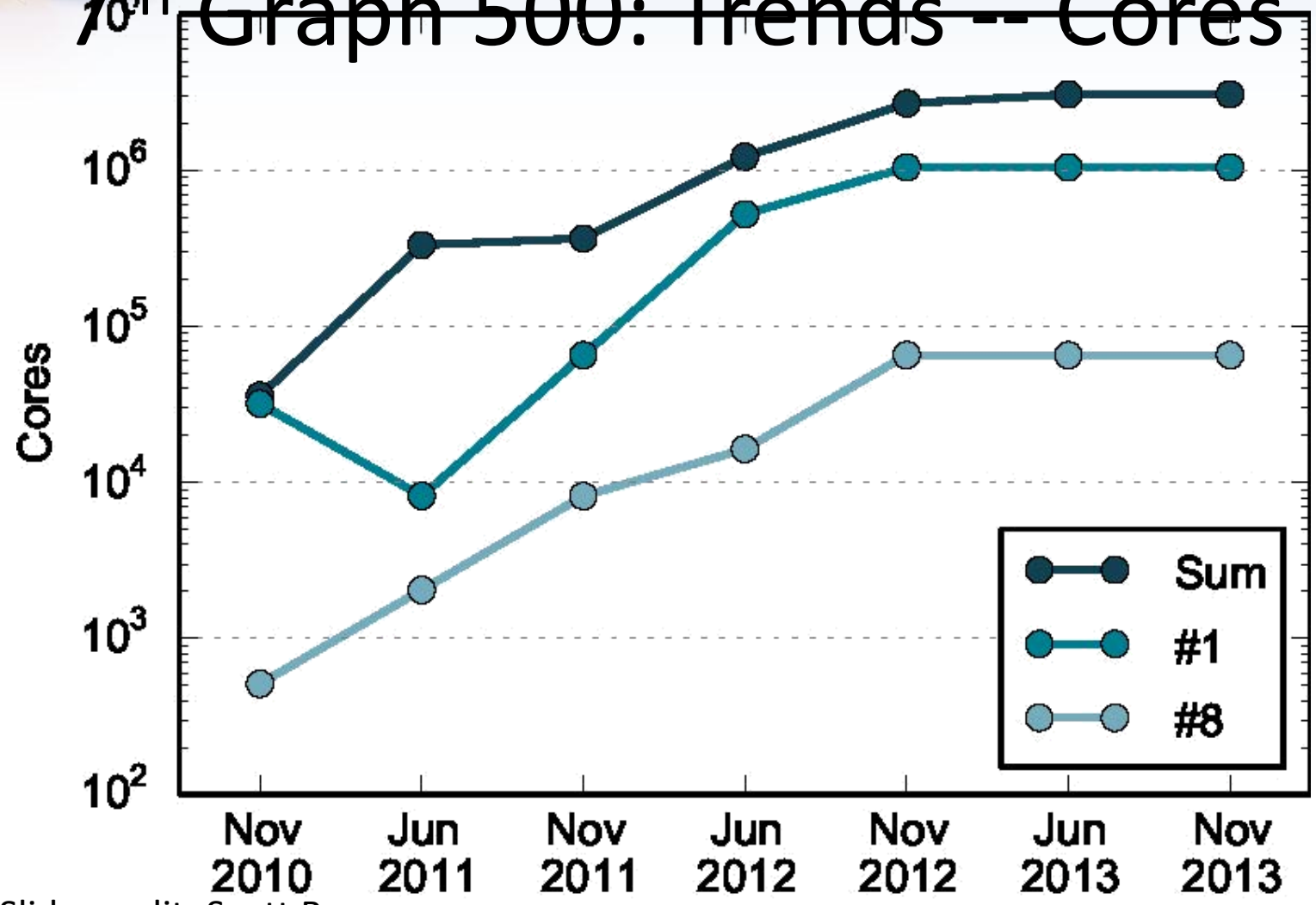
7th Graph 500: Trends -- Cores



Slide credit: Scott Beamer

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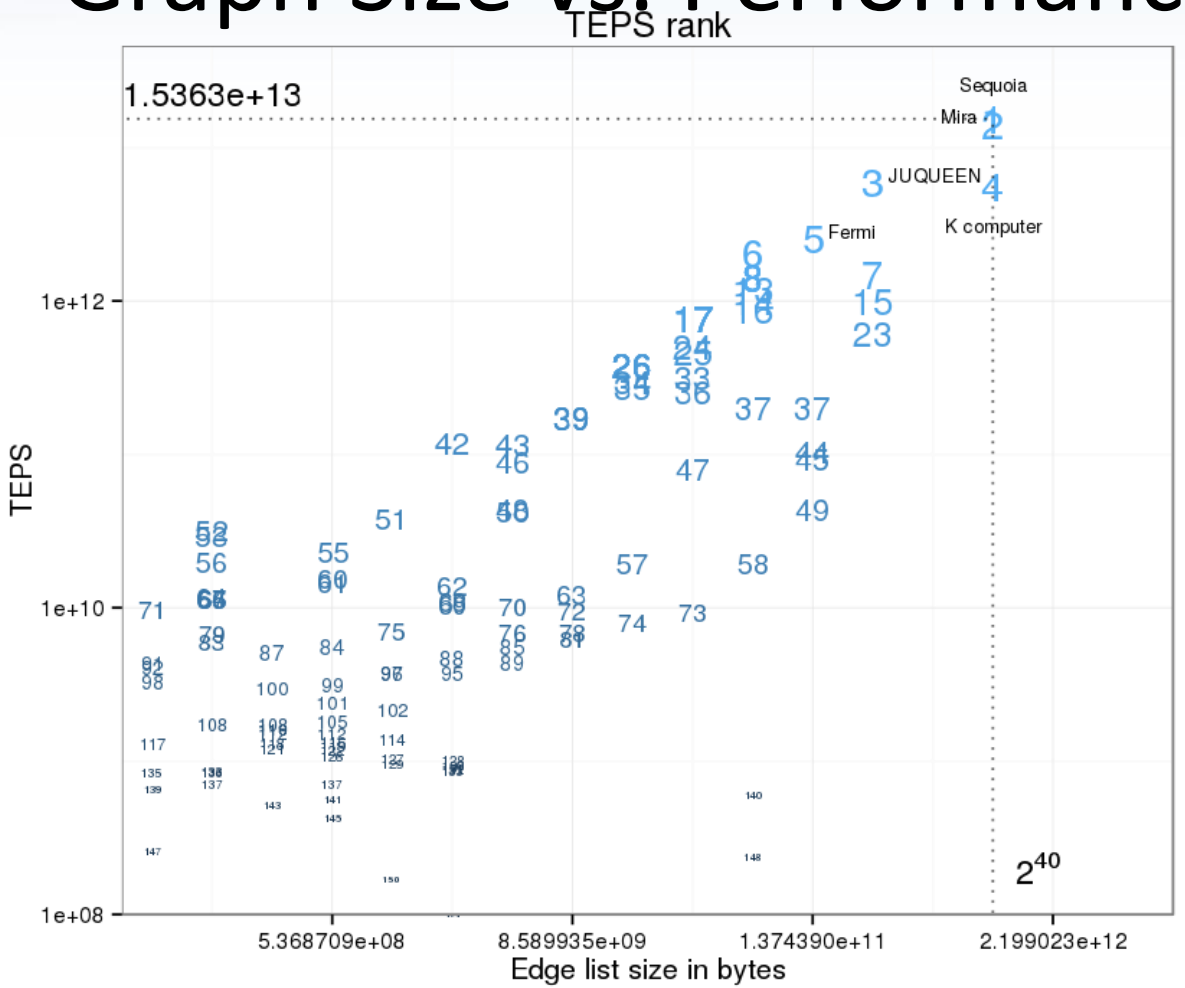
7th Graph500 List

Graph Size vs. Performance

Performance (Edges/Second), (TEPS)



Slide credit: Jason Riedy

Normalized Graph Data Structure Size

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Highlights of the 7th Graph500 List

- The list is growing!
- Top systems have leveled off
- Three vendors account for approximately half the list.
- Graph500 and Top500 rankings are not strongly correlated!
  - Top500's #1 system (Tianhe-2) is ranked #6 on Graph500
  - Graph500's #1 system (Sequoia) is ranked #3 on Top500

DISLIB

- Расширение SHMEM активными сообщениями
- Вместо shmem_put → shmem_send
- Прозрачная агрегация сообщений
- Эффективная реализация для кластеров с малореактивным интерконнектом
- Поддержка многоядерности

DISLIB History of Success

- 2009 NPB UA, dcmf version (BlueGene/P)
- 2010 GASNET-version (IB)
- 2011 Graph500 (BFS)
- 2011 MPI version +multicore optimized
- 2013 Quantum Computer
- 2014 Students, SSSP

```
#include "dislib.h”
int *data;
void allgather_hndl(int from, void* message, int size)
{  data[from] = * (int*)message; }
void main(int argc, char** argv)  {
   shmem_init(&argc,&argv);
   shmem_register_handler(allgather_hndl,1);
   data=malloc( sizeof(int) * num_pes() );
   data[my_pe()] = 57*my_pe();
   shmem_barrier_all();

   for(int i=0;i<num_pes();i++)
      shmem_send (data+my_pe(),1,sizeof(int),i);
   shmem_barrier_all();

   shmem_finalize();
}
```

BFS

```
if (VERTEX_OWNER(root) == my_pe()) {
    SET_VISITED(root);
    q1[0]=VERTEX_LOCAL(root);
    qc=1;
}
shmem_register_handler(visithndl,1);
shmem_barrier_all();
sum=1;
while(sum!=0) {
    for(i=0;i<qc;i++)
        for(j=g->rowsIndices[q1[i]];j<g->rowsIndices[q1[i]+1];j++)
            send_vertex(g->endV[j]);
    shmem_barrier_all();
    qc=q2c;q2c=0;int *tmp=q1;q1=q2;q2=tmp;

    sum=qc;
    shmem_long_allsum(&sum);
}
```

Active messages

```
void visithndl(int from, void* dat, int size) {
    int vloc = ((int*) dat)[0];
    if (!TEST_VISITEDLOC(vloc)) {
        SET_VISITEDLOC(vloc);
        q2[q2c++] = vloc;
    }
}

inline void send_vertex (int64_t glob) {
    int pe = VERTEX_OWNER(glob);
    int vloc = VERTEX_LOCAL(glob);
    shmem_send(&vloc,1,4,pe);
}
```

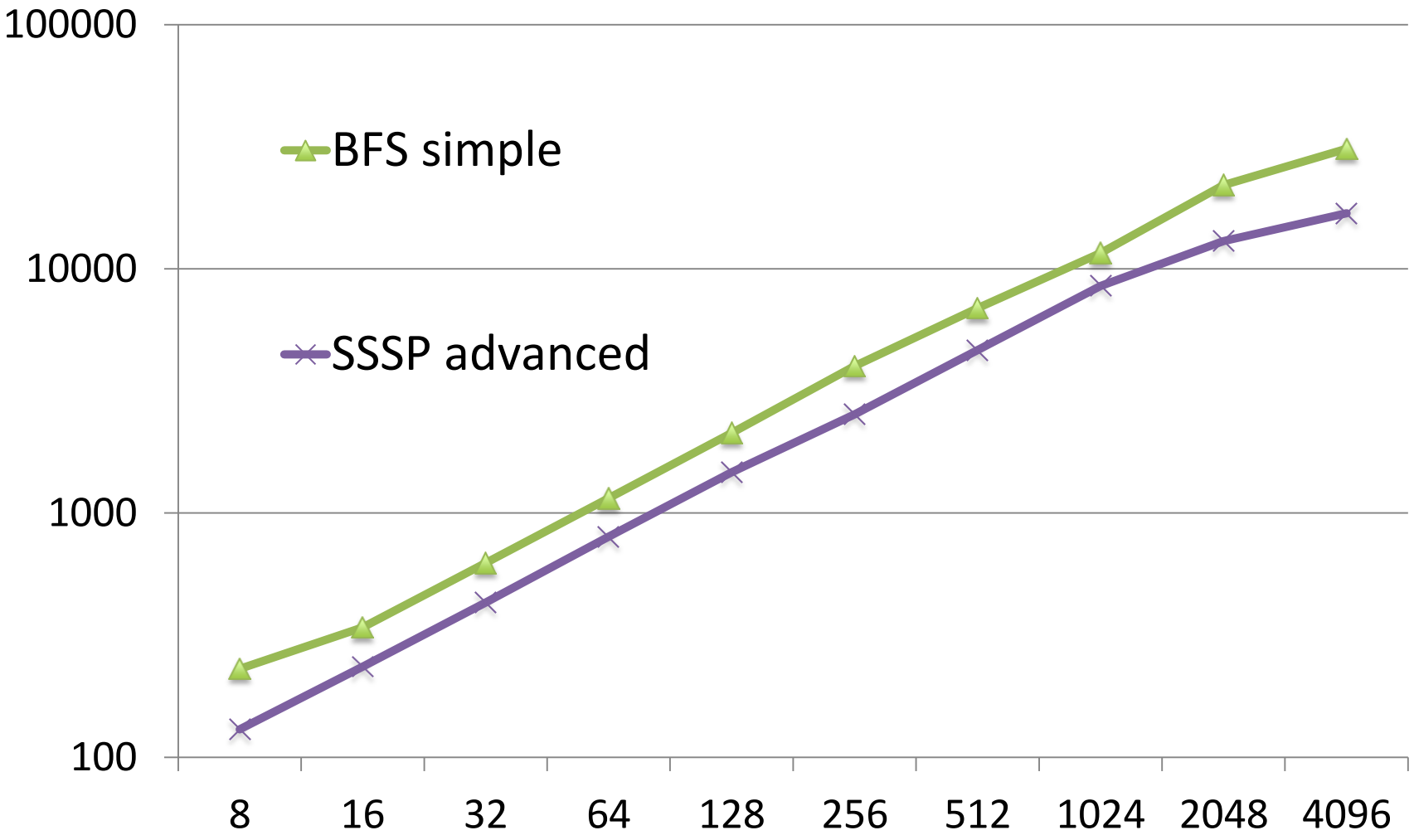
SSSP
Delta-stepping

```
while(sum!=0) {
    while(sum!=0) {
        for(i=0;i<qc;i++)
            for(j=g->rowsIndices[q1[i]];j<g->rowsIndices[q1[i]+1];j++)
                if(g->weights[j]<delta)      send_relax(g->endV[j],dist[q1[i]]+g->weights[j]);
        shmem_barrier_all();
        qc=q2c;q2c=0;int *tmp=q1;q1=q2;q2=tmp;
        sum=qc;
        shmem_long_allsum(&sum);
    }
    for(i=0;i<nlocalverts;i++)
        if(dist[i]>=glob_mindelta && dist[i] < glob_maxdelta) {
            for(j=g->rowsIndices[i];j<g->rowsIndices[i+1];j++)
                if(g->weights[j]>=delta)       send_relax(g->endV[j],dist[i]+g->weights[j]);
        }
    shmem_barrier_all();
    glob_mindelta=glob_maxdelta;
    glob_maxdelta+=delta;
    qc=0;sum=0;
    for(i=0;i<nlocalverts;i++)
        if(dist[i]>=glob_mindelta) {
            sum++;
            if (dist[i] < glob_maxdelta)       q1[qc++]=i;
        }
    shmem_long_allsum(&sum);
}
```

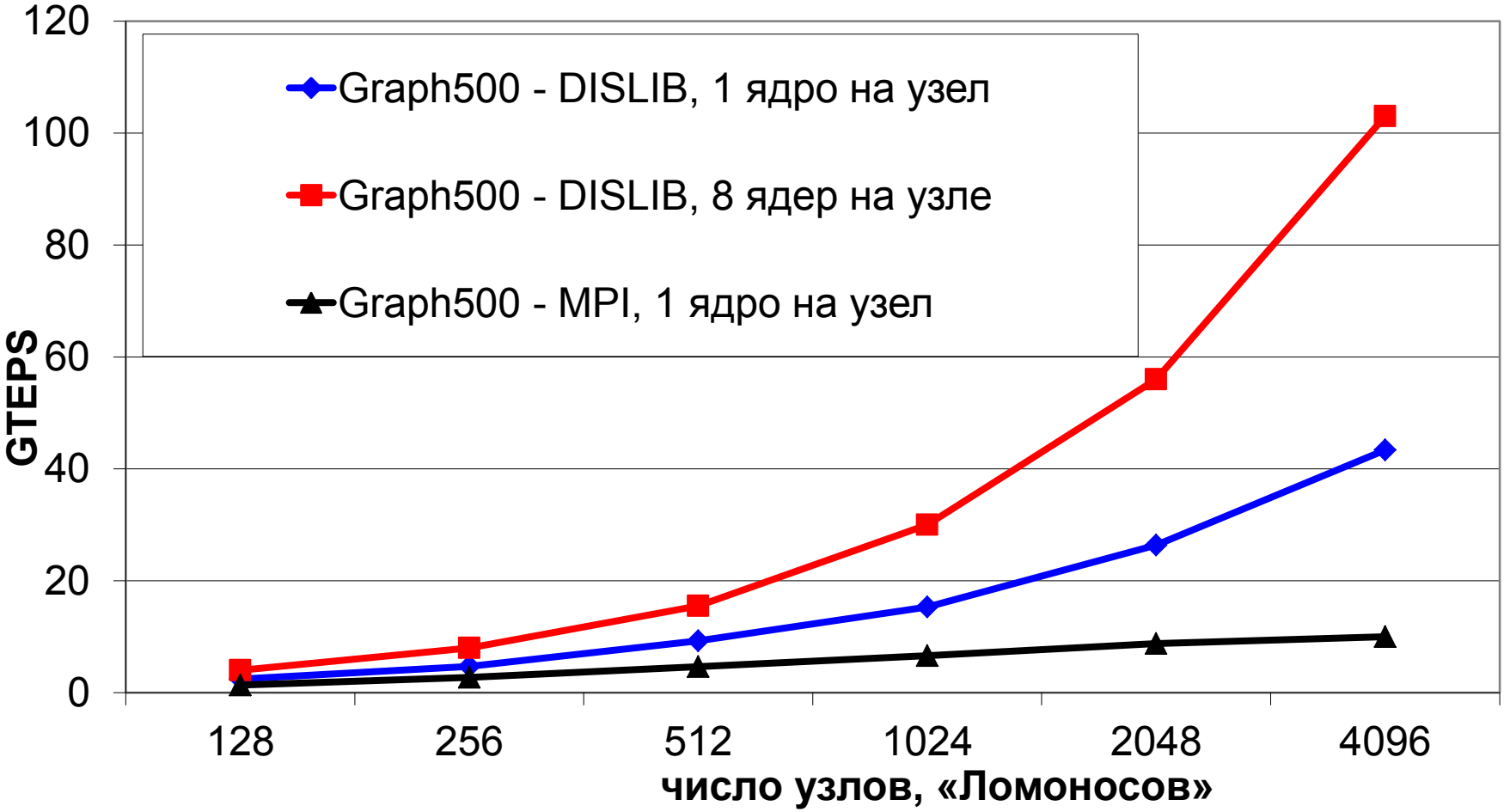
```
void relaxhndl(int from, void* dat, int size) {
    double w = ((double*) dat)[0];
    int vloc = ((int*) dat)[2];
    if (glob_dist[vloc] < 0 || glob_dist[vloc] > w) {
        glob_dist[vloc] = w;
        if(w < glob_maxdelta)        q2[q2c++] = vloc;
    }
}
void send_relax(int64_t glob, double weight) {
    int pe = VERTEX_OWNER(glob);
    int vloc[3];
    double* w = (void*)vloc;
    *w = weight;
    vloc[2] = VERTEX_LOCAL(glob);
    shmem_send(&vloc,2,12,pe);
}
```

```
void askhndl(int from, void* dat, int size) {
    int vloc = ((int*) dat)[0];
    int gfrom = VERTEX_TO_GLOBAL(from,((int*) dat)[1]);

    if(glob_dist[vloc]<glob_mindelta || glob_dist[vloc] >= glob_maxdelta)
                return;

    int j;
    for(j=glob_g->rowsIndices[vloc];j<glob_g->rowsIndices[vloc+1];j++)
        if(glob_g->endV[j]==gfrom) break; //first and lightest
    double ew=glob_g->weights[j];

    if(ew<glob_delta) return;

    int reply[3];
    double* ww = (void*)reply;
    *ww = glob_dist[vloc]+ew;
    reply[2] = vfrom;
    shmem_sendnb(reply,2,12,from,NULL,0);
}
```

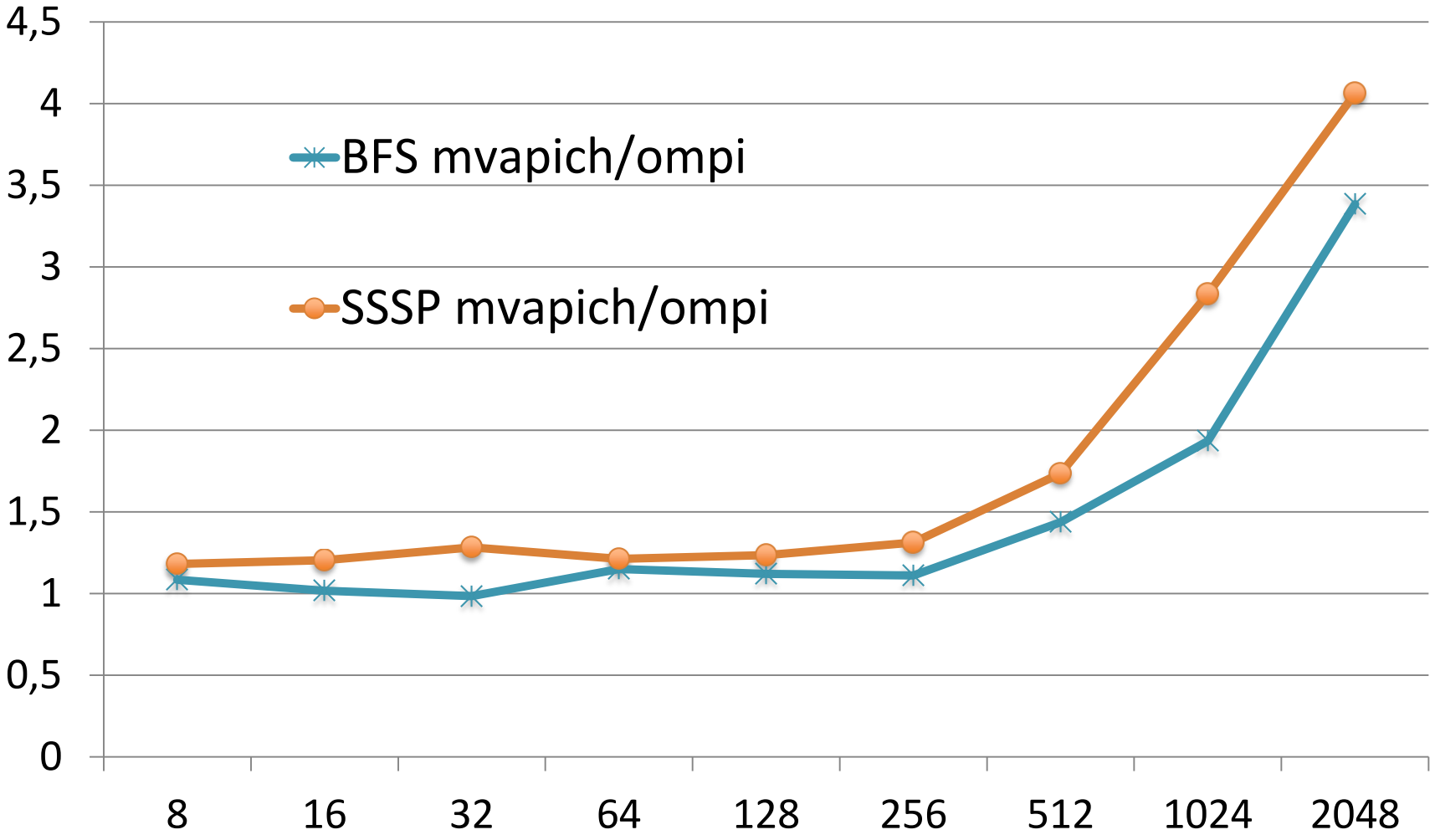
DISLIB weak scaling MTEPS/cores



Graph500 BFS, Nov/June 2011



DISLIB/MPI at scale



Try DISLIB

- Lomonosov : /opt/dislib
- /opt/dislib/graph (in few days)
- Feedback: anton@korzh.ru